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Bio-efficacy of various insecticides and botanicals against chilli thrips (*S. dorsalis* Hood) and their comparative cost: Benefit analysis in chilli crop

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Abstract
Bio-efficacy of four different insecticides (namely acephate, imidacloprid, cypermethrin, dimethoate) and three botanicals [namely *Allium sativum* extract, *Allium cepa* extract and NSKE] were investigated against chilli thrips. Among insecticides, imidacloprid 17.8 SL reduced maximum thrips population (82.46%) followed by acephate 75 SP (80.86%). Among botanicals, NSKE 5% caused maximum mortality of 64.50%, while garlic and onion extract showed comparatively less performance with 55.98% and 51.53% respectively. Among all treatments, the highest percent increase in yield over control was obtained from plots treated with imidacloprid 17.8 SL (45.42%) followed by cypermethrin 12.5 EC (38.15%). Amongst botanicals, greater percent increase in the yield was recorded by application of *A. sativum* extract (34.46%), followed by *A. cepa* extract (22.33%). The C: B ratio for all treatments was analyzed and found to be highest in case of imidacloprid 17.8 SL (1:16.66) whereas the lowest in case of dimethoate 0.03 EC (1:7.39).

Keywords: Chilli thrips, insecticides and botanicals, efficacy, yield, C: B ratio

1. Introduction
Chilli, *Capsicum annuum* L. (Solanaceae) is a very popularly grown spice crop in most of tropical and sub-tropical countries. The chilli crop was thought of to be native of India but in reality, it was originated from South America and brought to India by Portuguese during 15th century [1]. Chilli is one of the largest grown cash crop in Asia and also very widely used in India by inform of both raw and processed products due to its 'capsaicin' content that gives burning sensation in taste. In addition to its culinary uses, it has high medicinal value against day-to-day infectious diseases. In India the productivity of chilli is very low due to several factors among which insect and mite pests are most destructive [2]. Continuous change in insect-pest trend became barrier in its growth and cultivation. The major insects that attacked chilli are mites (*Polyphagotarsonemus latus* Banks), thrips (*Scirtothrips dorsalis* Hood), aphids (*Myzus persicae* Sulzer and *Aphis gossypii* Glover) and Fruit borer (*Helicoverpa armigera*) etc. Among the above insects, due to chilli thrips and mites only the estimated loss tuned upto 50 per cent [3, 4].

Chilli thrips, *S. dorsalis* is one of the destructive pests of chilli and also an important pest of various vegetable, ornamental and fruit crops in southern and eastern Asia [5, 6]. Chilli thrips appeared in field just few weeks after transplanting and incidence was more at early winter [7]. Thrips mostly attack the upper ground parts and prefers young leaves, bods and also flowers. Both the nymph and adults suck the cell sap from the ventral part of leaves; due to this the characteristic up-wording curling of leaves occurred. In case of severe infestation, the tender leaves and buds get brittled, resulting in complete defoliation and total crop loss. Infested fruits also develop corky tissues [8].

In modern pest management practices due to continuous use of the chemical insecticides, most of them are now failing to reduce this pest incidence [9]. Also due to heavy (more than recommended dose) and frequent application of insecticides, the insect-pests started developing resistance against different formulations and this leads to breakout of thrips causing serious havoc. Along with the pest control it is necessary to care for the safety of the natural enemies and other beneficial insects (pollinators). So to avert these critical situations, the present study was conducted with an objective to evaluate the efficacy of some botanicals (plant derived formulations) against the chilli thrips along with some popular insecticides recommended against thrips. In this investigation the yield obtained from plots sprayed with

different treatments were compared and the beneficial curative option for the control of chilli thrips will be recommended.

2. Materials and Methods

2.1 Experimental setup

The present experiment was carried out in the field condition of Vegetable Research Farm of Institute of Agricultural Sciences, Banaras Hindu University. The research farm was situated approximately in the centre of North Gangetic alluvial plains (24° 56' N to 25° 35' N Latitude; 82° 14' E to 83° 24' E Longitude). The overall climatic condition was subtropical in nature which got a good shower of rain during *kharif* season and a scanty shower on *rabi* season also. The chilli variety 'G-4' was raised in nursery with raised beds and proper plant protection care was taken to avoid seedling death. The 30-35 days old seedlings were then transplanted in main field with plot size of 3m × 2m each during first week of August 2015. All the recommended cultural practices were followed with proper fertilization and irrigation process. The experimental design followed was Randomized Block Design (RBD), with 8 treatments and 3 replications of each one.

2.2 Preparation and application of treatments

There was eight number of treatments consisting 4 insecticides viz. acephate 75 SP, imidacloprid 17.8 SL, cypermethrin 12.5 EC, dimethoate 0.03 EC and three botanicals *viz*. garlic (*A. sativum*) extract, onion (*A. cepa*) extract, NSKE 5% with one control plot (sprayed with normal water). The desired doses of insecticides were added in water and mixed well before spraying. For botanicals, both onion and garlic were grinded by means of electric grinder and wooden mortar and pestle to a fine smooth paste. Then the content was sieved with a muslin cloth, one kilogram (1kg) each of the grinded extracts were mixed with two liters of ethanol and kept for 24 hours [10]. The supernatant was collected carefully and used as treatment (at 100% concentration). The first spraying of treatments were done when thrips population started crossing ETL level at about 27- 30 days after transplanting and second spraying was after 45-47 days of transplanting. The spraying was done with the help of hand operated knapsack sprayer during evening hours when the air drift was less.

2.3 Observation and analysis of data

2.3.1 For bio-efficacy study

The sampling was done form five randomly selected and tagged plants from each plot with plucking 3 leaves per plant *i.e.* from upper, middle and lower portion of the plant [11, 12]. The observation of thrips was taken one day prior to the application of treatments and then 1, 3, 7 and 10 days after the spraying. The collected leaf samples were brought to laboratory in separate zip-locked poly-bags and the number of thrips was counted under stereoscopic binocular microscope. The percent thrips reduction was calculated by using formula

$$\% \text{ reduction in population} = \frac{\text{Average reduction in population}}{\text{Average pretreatment population}} \times 100$$

The mean percentage reduction values obtained from different plots (treatments) was transformed into Acr-sine form and then the significant effect of the treatments on mortality of thrips was compared by means of critical difference (CD) values at 5% level of significance. The data were statistically analysed using OPSTAT online statistical programme.

2.3.2 For Yield estimation

The red-ripe matured chilli fruits were harvested plot wise by two to three pickings and weighed separately by means of manual weighing machine. The recorded weight was converted to kg/ ha or t/ ha. The per cent increase in yield over control in various treatments was calculated by using the following formula [13]

$$\% \text{ increase in yield over control} = \frac{\text{Yield in treatment - Yield in control}}{\text{Yield in control}} \times 100$$

2.3.3 Benefit cost ratio (BCR)

The healthy marketable yield obtained from different treatments was collected separately and weighed. The cost of insecticides used in this experiment was recorded during *kharif* season of 2015-16. The cost of botanicals used was obtained from nearby market. The total cost of plant protection consisted of cost of treatments, sprayer rent and labour charges for the spray. There were two sprays throughout the research period and the overall plant protection expenses were calculated. Total income will be realized by multiplying the total yield per hectare by the prevailing market price; while the net benefit is obtained by subtracting the total cost of plant protection from total income. Benefit over the control for each sprayed treatment was obtained by subtracting the income of the control treatment from that of each sprayed treatment [10]. The B:C ratio can be calculated by formula-

$$\text{B: C Ratio} = \frac{\text{Net benefit over control}}{\text{Total cost of protection}}$$

3. Results and Discussion

3.1 Effect of insecticides and botanicals against chilli thrips (*S. dorsalis*)

First spray- After the first spraying the highest reduction in thrips population was seen in plots treated with imidacloprid 17.8 SL (72.56%), followed by acephate 75 SP (72.56%) and dimethoate 0.03 EC (70.35%) (Table 1)(Figure 1). But in case of botanicals, NSKE 5% proved superior in controlling the thrips population upto 53.62%, followed by *A. cepa* extract (72.56%) and *A. sativum* extract (44.73%). Similar trend of population reduction was seen in both 3rd and 7th days after spraying with maximum reduction of (82.76% and 90.38%) by imidacloprid 17.8 SL, followed by acephate 75 SP (81.87% and 88.08%) respectively [14, 15]. But after 3rd and 7th days of spraying, cypermethrin 12.5 EC showed better performance than dimethoate 0.03 EC with mortality of 78.84% and 84.65% respectively. The mortality caused by the botanicals was comparatively less than the insecticide. Among the botanicals, NSKE 5% caused maximum percent thrips reduction on 3rd and 7th days after spraying *i.e.* about 64.28 and 67.84% respectively. On 10th days after spraying the performance of all insecticides started decreasing gradually, but efficacy of imidacloprid 17.8 SL remained effective with reduction of 84.54% thrips. The lowest percent reduction was shown by dimethoate 0.03 EC (68.82%) and among botanicals, plots treated with extracts of *A. cepa*. In control plots there was no reduction of population, rather the population increased to 140-150 per 15 leaves per plot.

3.1.1 Second spray: The result obtained on one day after the spray showed a reduction of 75.54%, 73.36% and 72.89% thrips respectively in plots treated with imidacloprid 17.8 SL, acephate 75 SP and dimethoate 0.03 EC [15, 16, 17]. The comparative efficacy data of all the treatments have been

clearly described in Table 1& Figure 1. There was no significant difference in mortality caused by the chemicals. In case of botanicals NSKE 5% caused 57.65% mortality and the other two performed below 50%. On 3 and 7 days after spraying there was significant increase in performance of all chemicals, with highest thrips mortality by imidacloprid 17.8 SL (82.38%, 84.73%) and lowest by dimethoate 0.03 EC (78.32%, 69.58%) respectively, whereas cypermethrin 12.5 EC showed greater percent reduction (84.19%) i.e. similar to imidacloprid 17.8 SL [18]. Among botanicals, significant increase in efficacy was shown in NSKE 5% *i.e.* from 66.48 to 71.43%, from 3rd to 7th days after spraying. On 10 days after spraying there was a little rise in thrips population due to decrease in efficiency of the insecticides. But still better control was given by imidacloprid 17.8 SL and acephate 75 SP with above 80% of population reduction. Botanicals also lost their efficacy with 68.28% reduction in NSKE 5% plots, followed by 53.94% in *A. sativum* extract and 48.76% in *A. cepa* extract sprayed plots respectively. There was continuous increase in thrips population in control plots throughout the crop season, because there was no distinct reduction in population (Table 1).

The insecticides and the botanicals can be ranked in relation to their efficacy in reducing the thrips population. According to the pooled mean percent reduction in thrips population after two sprays, the best thrips control was given by imidacloprid 17.8 SL (82.46%) > acephate 75 SP (80.86%) > cypermethrin 12.5 EC (77.12%) > dimethoate 0.03 EC (71.48%) > NSKE 5% (64.50%) > *A. sativum* extract (55.98%) > *A. cepa* extract (51.53%) (Table 1).

Table 1: Efficacy of various insecticides and botanicals against chilli thrips (*S. dorsalis*) in the year, 2015-16.

Treatments (Chemicals and Botanicals)	Doses (g a.i/ha)	PTP	Percent reduction in thrips population/15 leaves/plot											Pooled Mean% reduction
			1st Spray					PTP	2nd Spray					
			1 DAS	3 DAS	7 DAS	10 DAS	Mean		1 DAS	3 DAS	7 DAS	10 DAS	Mean	
Acephate 75 SP	350	19.58	72.56* (67.35)	81.87 (76.84)	88.08 (83.36)	80.82 (74.02)	80.83	13.58	73.36 (68.31)	80.13 (73.96)	87.54 (81.13)	82.54 (77.47)	80.89	80.86
Imidacloprid 17.8 SL	20	22.8	76.66 (72.58)	82.76 (77.73)	90.38 (87.37)	84.54 (79.48)	83.59	19.24	75.54 (71.83)	82.38 (77.24)	84.73 (79.94)	82.68 (77.61)	81.33	82.46
Cypermethrin 12.5 EC	60	35.86	69.32 (62.56)	78.84 (72.61)	84.65 (79.86)	71.86 (66.26)	76.17	23.52	70.77 (63.52)	76.46 (71.36)	84.19 (79.02)	80.88 (74.34)	78.08	77.12
Dimethoate 0.03 EC	300	40.91	70.35 (65.98)	76.35 (71.25)	74.71 (69.65)	68.82 (62.39)	72.56	29.90	72.89 (67.87)	78.32 (72.38)	69.58 (63.88)	60.83 (56.41)	70.41	71.48
Allium sativum	100	31.14	44.73 (40.65)	64.67 (60.63)	62.36 (58.95)	58.66 (53.33)	57.61	28.34	48.35 (43.28)	55.76 (51.48)	59.37 (53.54)	53.94 (49.88)	54.36	55.98
Allium cepa	100	20.66	46.19 (41.74)	58.97 (52.95)	52.68 (49.38)	47.59 (42.18)	51.36	17.75	46.23 (41.34)	54.66 (50.12)	57.16 (52.13)	48.76 (43.58)	51.70	51.53
NSKE 5%	5	12.32	53.62 (49.77)	64.28 (60.24)	67.84 (62.55)	66.41 (61.62)	63.04	16.63	57.65 (52.63)	66.48 (61.74)	71.43 (66.34)	68.28 (62.12)	65.96	64.50
Control (Water)		26.38	0	0	0	0		63.25	0	0	0	0		
SEM±			1.38	1.73	1.08	0.86			1.23	1.47	0.98	1.86		
CD(p=0.05)	–		2.84	3.24	2.79	2.12			2.59	2.73	2.25	3.08		

PTP- Pre-treatment population, **DAS**- Days after spraying, * Mean percent reduction from three replications, Values in the parenthesis are Acr-sine transformed

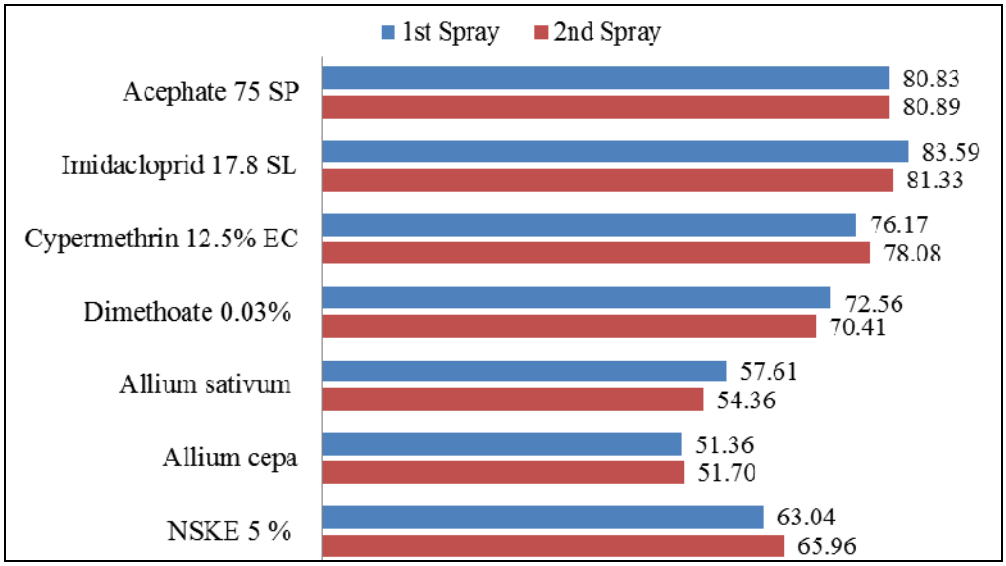

Fig 1: Mean% reduction of thrips after 1st and 2nd spraying of the treatments.

3.2 Effect of Insecticides and Botanicals on chilli yield

The yield obtained from the experimental plots varies from 1565.52 kg/ha in control plot to 2278.63 kg/ha in plots treated with imidacloprid 17.8 SL. Among the insecticides, plots treated with imidacloprid 17.8 SL provide maximum yield followed by cypermethrin 12.5 EC (2164.55 kg/ha) and dimethoate 0.03 EC (1920.84 kg/ha) (Table 2). Among the botanicals highest fruit yield was produced from plots treated with A. sativum extract (2106.52 kg/ha) followed by NSKE 5% (1862.48 kg/ha). There was not much significant difference in fruit yield obtained from plots treated with chemical insecticides. The percent increase in yield over control was maximum in imidacloprid 17.8 SL (45.42%) followed by cypermethrin 12.5 EC (38.15%) and dimethoate

0.03 EC (22.63%) (Figure 2). Among botanicals the comparatively greater percent increase in yield was recorded from A. sativum extract treated crops 34.46% (close to cypermethrin 12.5 EC), followed by A. cepa extract treated crops (22.33%). Therefore, it's better to use botanicals rather than chemical insecticides for control of thrips incidence in chilli crop.

Table 2: Effect of the insecticides and botanical on improving yield over control

Treatments (Insecticides and Botanicals)	Yield (kg/ha)	Total Yield (t/ha)	Increase in yield over control (%)
Acephate 75 SP	1882.34	1.882	20.18
Imidacloprid 17.8 SL	2278.63	2.279	45.42
Cypermethrin 12.5 EC	2164.55	2.165	38.15
Dimethoate 0.03 EC	1920.84	1.921	22.63
Allium sativum	2106.52	2.107	34.46
Allium cepa	1947.46	1.947	24.33
NSKE 5%	1862.48	1.862	18.91
Control (Water)	1565.52	1.566	-

3.3 Benefit: Cost ratio analysis

During the period of experiment the market value of the treatments and total fruit yield was recorded and the benefit obtained over the plant protection expense was analyzed (Table 3). Among the insecticides, the highest benefit in terms of money was obtained from the plots applied with imidacloprid 17.8 SL with C: B ratio 1:16.66. The next best treatment in terms of benefit obtained was cypermethrin 12.5 EC which provide greater yield in comparison to the cost of plant protection measure and the benefit over a single rupee spent was 12.31 [10, 14]. Acephate 75 SP and dimethoate 0.03 EC were lagging behind in term of the benefits provided by other chemicals. The acephate 75 SP provide a C:B ratio of 1: 9.34 followed by the dimethoate 0.03 EC with C:B ratio of (1:7.39). Similar benefits obtained from acephate and dimethoate was recorded by Patel *et al*., 2009. Among botanicals the greater benefit in yield as well as plant protection was obtained from plots treated with garlic (*A. sativa*) extracts with a C:B value of (1:10.36), that was quite closer to the benefits obtained from the insecticides, but not at par [10]. Followed by that NSKE 5% was proved superior to the onion (*A. cepa*) extract in terms of benefit with a C: B ratio of 1:9.96 and 1:8.81 respectively (Table 3). According to the above results obtained, the treatments can be arranged in a descending order on basis of CBR as follows; Imidacloprid 17.8 SL > Cypermethrin 12.5 EC > *A. sativa* extracts > NSKE 5% > Acephate 75 SP > *A. cepa* extract > Dimethoate 0.03 EC.

Table 3 C**:** B ratio of the insecticides and botanicals used against chilli thrip

Treatments	Yield (t/ha)	Total Plant protection Expense (Rs/ha)	Total/ Gross Income (Rs)	Net benefit in income (Rs/ha)	Benefit over control (Rs/ha)	C:B ratio (CBR)
Acephate 75 SP	1.88	1842	112940	111098	17198.40	1:9.34
Imidacloprid 17.8 SL	2.28	2425	136718	134293	40392.80	1:16.66
Cypermethrin 12.5 EC	2.16	2702	129873	127171	33271	1:12.31
Dimethoate 0.03 EC	1.92	2545	115250	112705	18805.40	1:7.39
Allium sativum	2.11	2861	126391	123530	29630.20	1:10.36
Allium cepa	1.95	2340	116848	114508	20607.60	1:8.81
NSKE 5%	1.86	1628	111749	110121	16220.80	1:9.96
Control (Water)	1.57	-	93900	93900	-	-

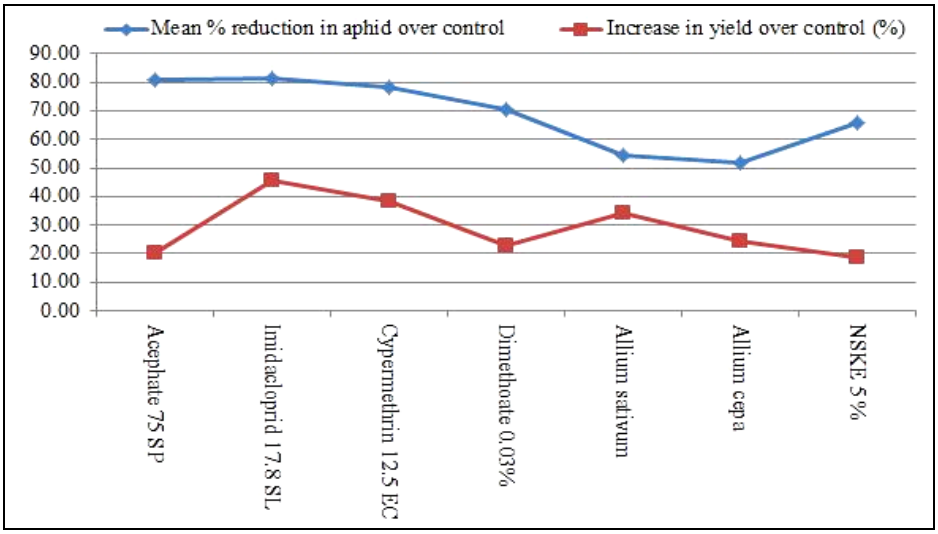

Fig 2: Comparative studies between mean% reduction of thrips and% increase in yield of chilli, by application of treatments

4. Conclusion

The above experiment revealed that all the treatments showed significant effective performance against thrips population in the first as well as second spraying. The thrips population reduction was highest in plots treated with followed by acephate 75 SP and among botanicals with *A. sativum* extract proved to be superior to *A. cepa* extract and NSKE 5%. From the comparative study it was clearly concluded that, the decrease in thrips population causes significant increase in yield over control. They showed a positive co-relation with each other and the greater increase in fruit yield was recorded in case of crops treated with imidacloprid 17.8 SL. The cost benefit analysis of the treatments confirmed that the net benefit obtained over one rupee spent was highest in case imidacloprid 17.8 SL, so it was economical to use it against thrips. At the same period *A. sativum* extract provided benefit that was very close to the imidacloprid 17.8 SL and being a botanical, it has no ill effect on plants as well as environment. So it could be highly recommend to farmers as it is less costly, ecofriendly and efficient in chilli thrips management.

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